US005803029A

United States Patent [19]

Yoshihara et al.

[11] **Patent Number: 5,803,029**

[45] **Date of Patent: Sep. 8, 1998**

[54] **VALVE PERFORMANCE CONTROLLER FOR INTERNAL COMBUSTION ENGINE**

[75] Inventors: **Yuji Yoshihara**, Toyota; **Hiroyuki Kawase**, Okazaki; **Yuichi Sakaguchi**, Nagoya; **Kouichi Shimizu**; **Hiromasa Suzuki**, both of Toyota, all of Japan

[73] Assignee: **Toyota Jidosha Kabushiki Kaisha**, Toyota, Japan

[21] Appl. No.: **927,224**

[22] Filed: **Sep. 10, 1997**

[30] **Foreign Application Priority Data**

Sep. 11, 1996 [JP] Japan 8-240240

[51] **Int. Cl.**^{6} **F02D 13/02**; F01L 1/34; F01L 13/00

[52] **U.S. Cl.** **123/90.16**; 123/90.17; 123/90.15

[58] **Field of Search** 123/90.12, 90.15, 123/90.16, 90.17, 90.22, 90.31, 90.39

[56] **References Cited**

U.S. PATENT DOCUMENTS

5,031,583 7/1991 Konno 123/90.16
5,497,737 3/1996 Nakamura 123/90.16

FOREIGN PATENT DOCUMENTS

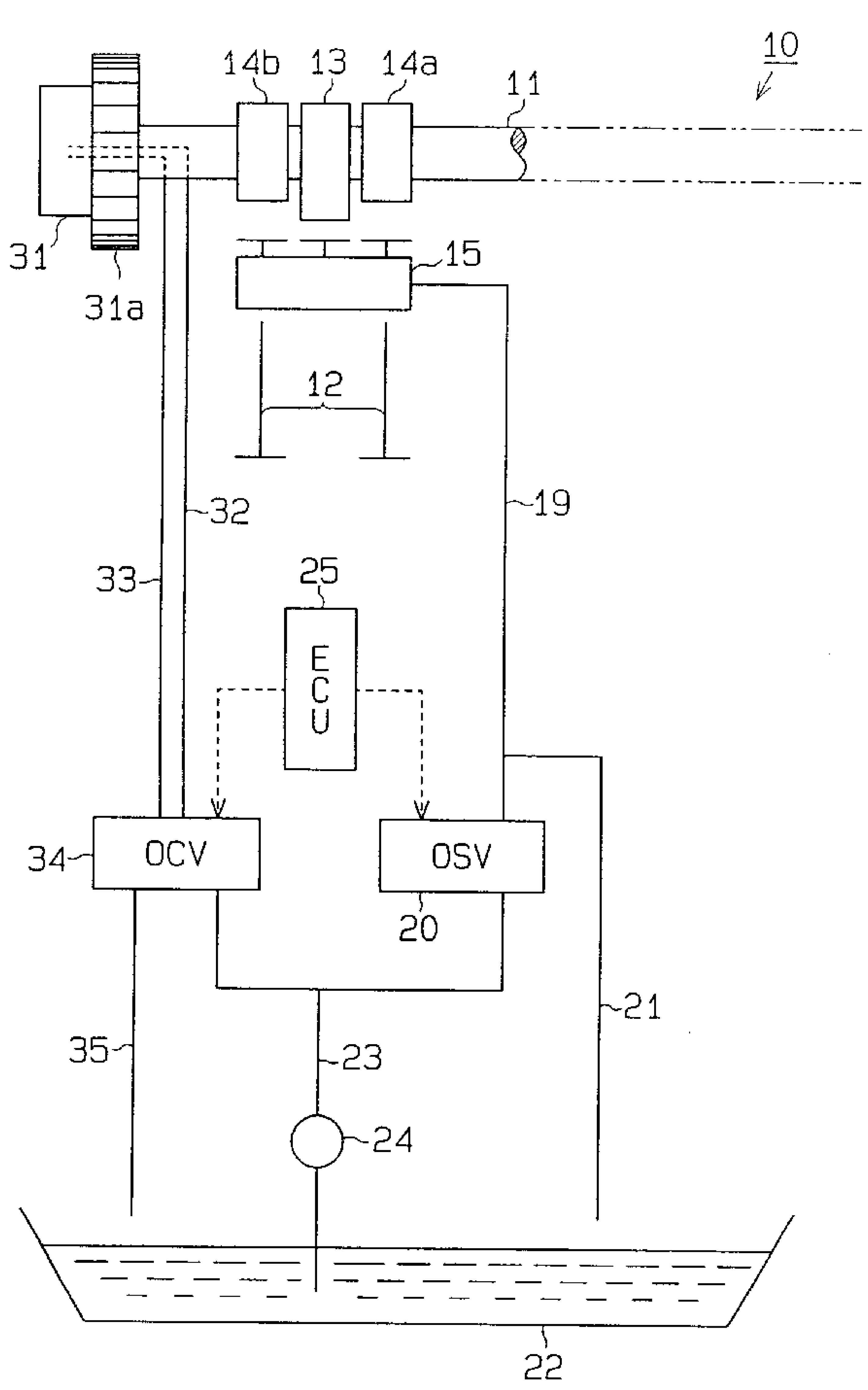
8-14015A 1/1996 Japan .
8-28219A 1/1996 Japan .
8-49514A 2/1996 Japan .

Primary Examiner—Weilun Lo
Attorney, Agent, or Firm—Kenyon & Kenyon

[57] **ABSTRACT**

There is disclosed a valve performance controller for an internal combustion engine. A camshaft is provided with a plurality of cams having different cam profiles. Changeover of the cams is performed through operation of a valve lift control mechanism. Also, a valve timing control mechanism is provided on the camshaft. The valve timing mechanism has a pulley, which is connected to a crankshaft of the engine via a timing belt. The pulley is connected to the camshaft via a ring gear. Through movement of the ring gear along the axis of the camshaft, the relative rotational phase between the pulley and the camshaft is changed. At least during cam changeover operation, oil is charged and retained within the hydraulic chamber located on both sides of the ring gear in the moving direction thereof. This structure reduces an impact which acts on the timing belt upon changeover of the cams.

12 Claims, 5 Drawing Sheets



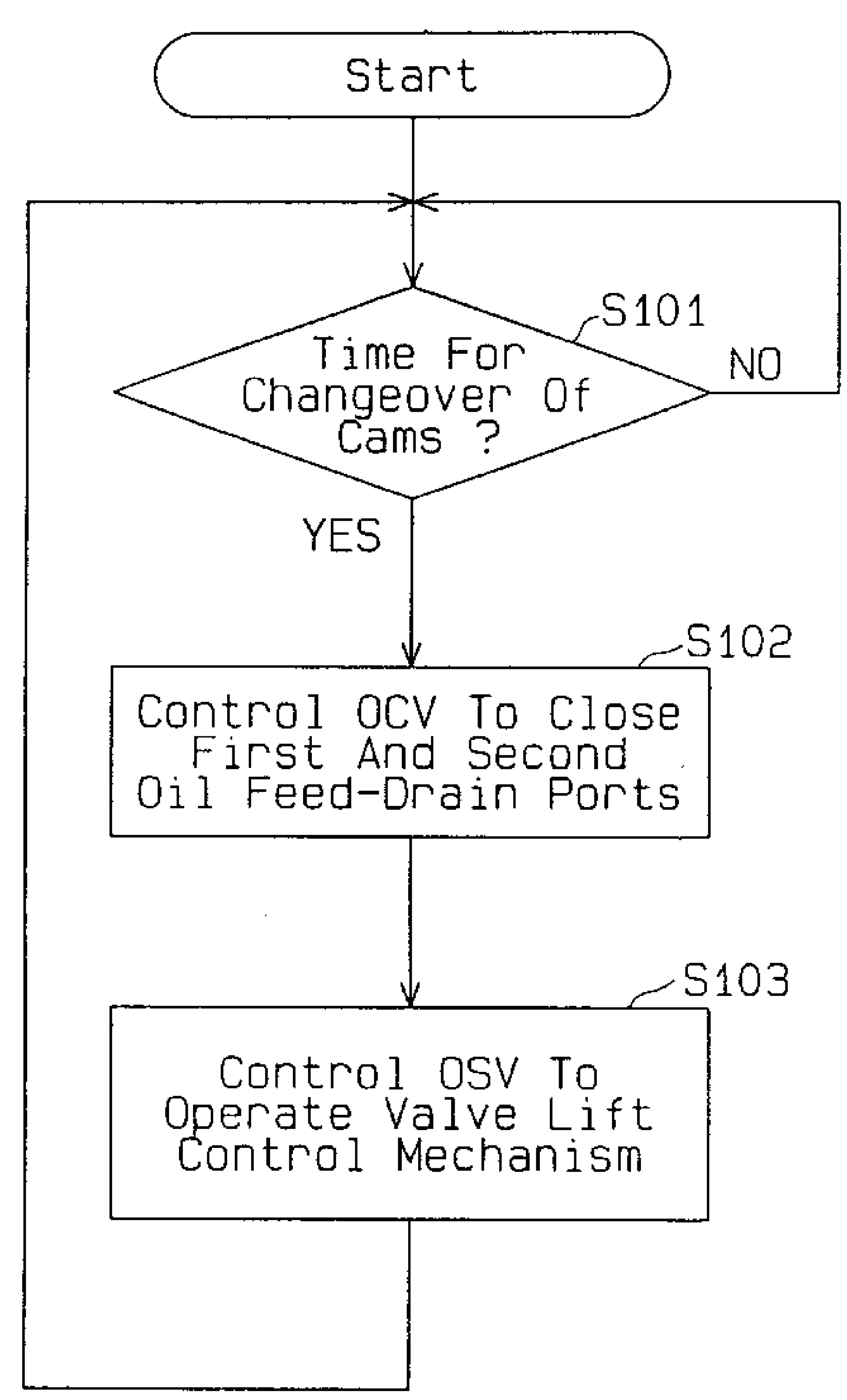


Fig.1

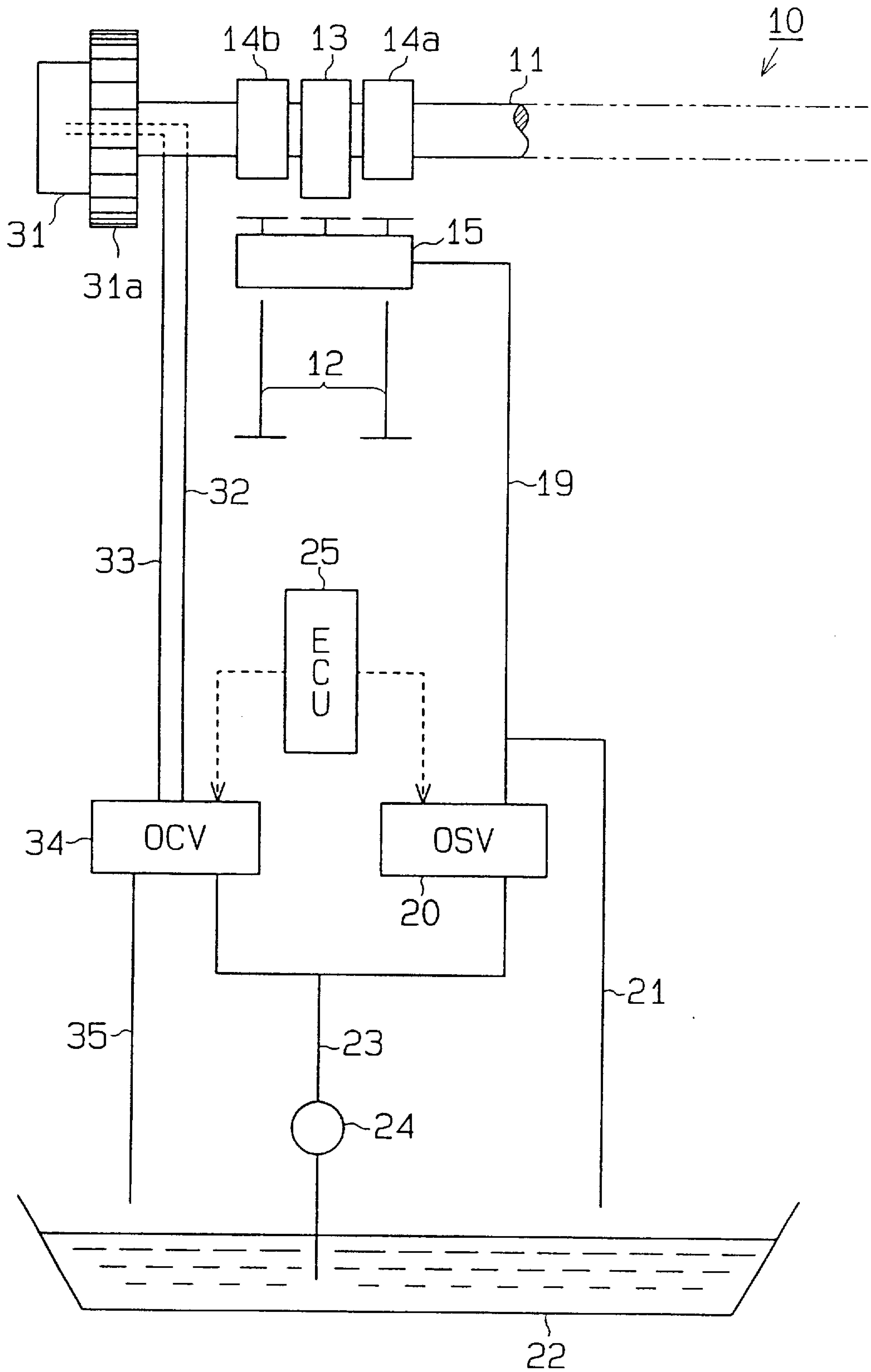

10
14b
13
14a
11
31
31a
15
12
32
19
33
25
ECU
34
OCV
OSV
20
21
35
23
24
22

Fig.2

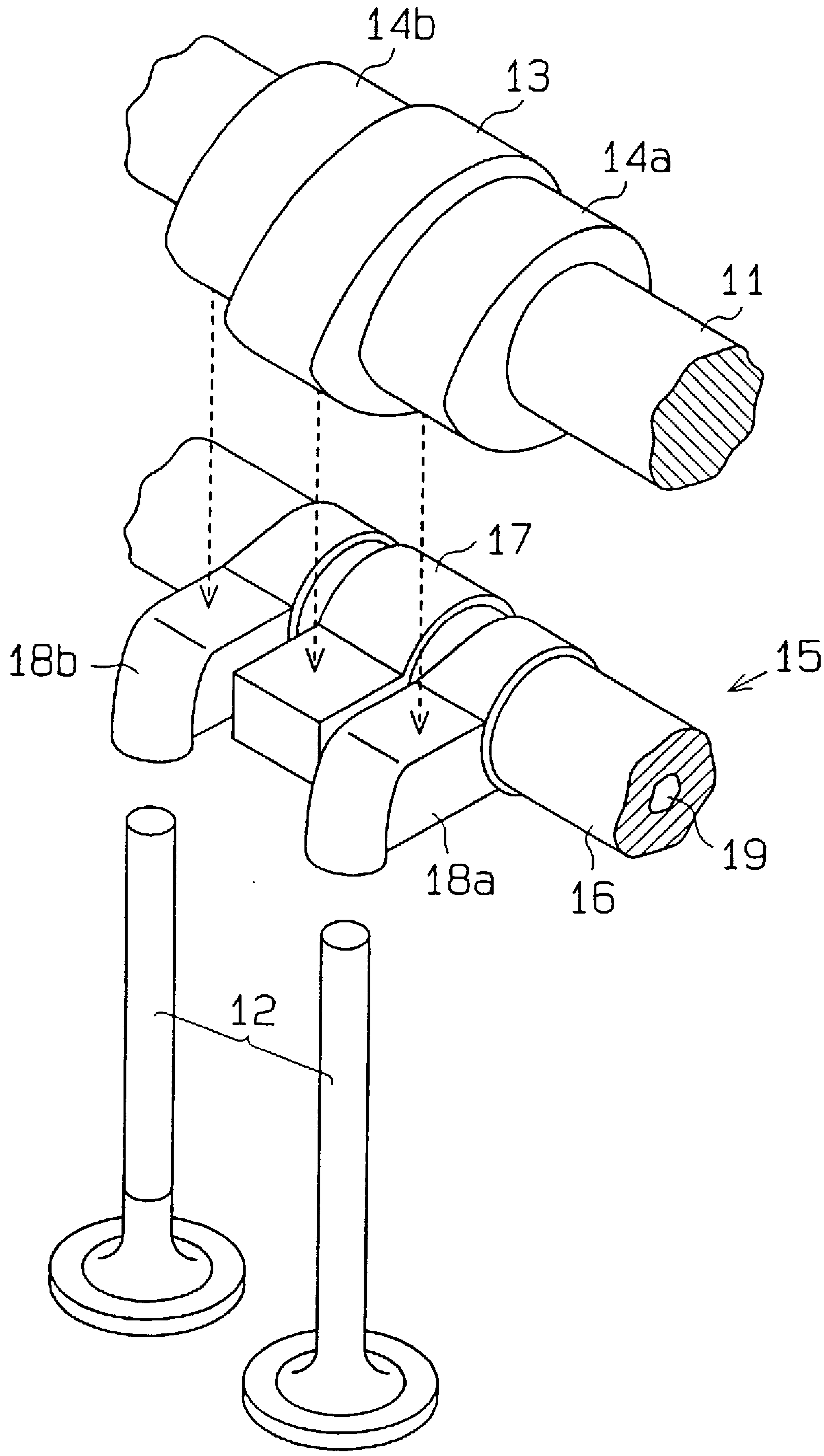


Fig.3

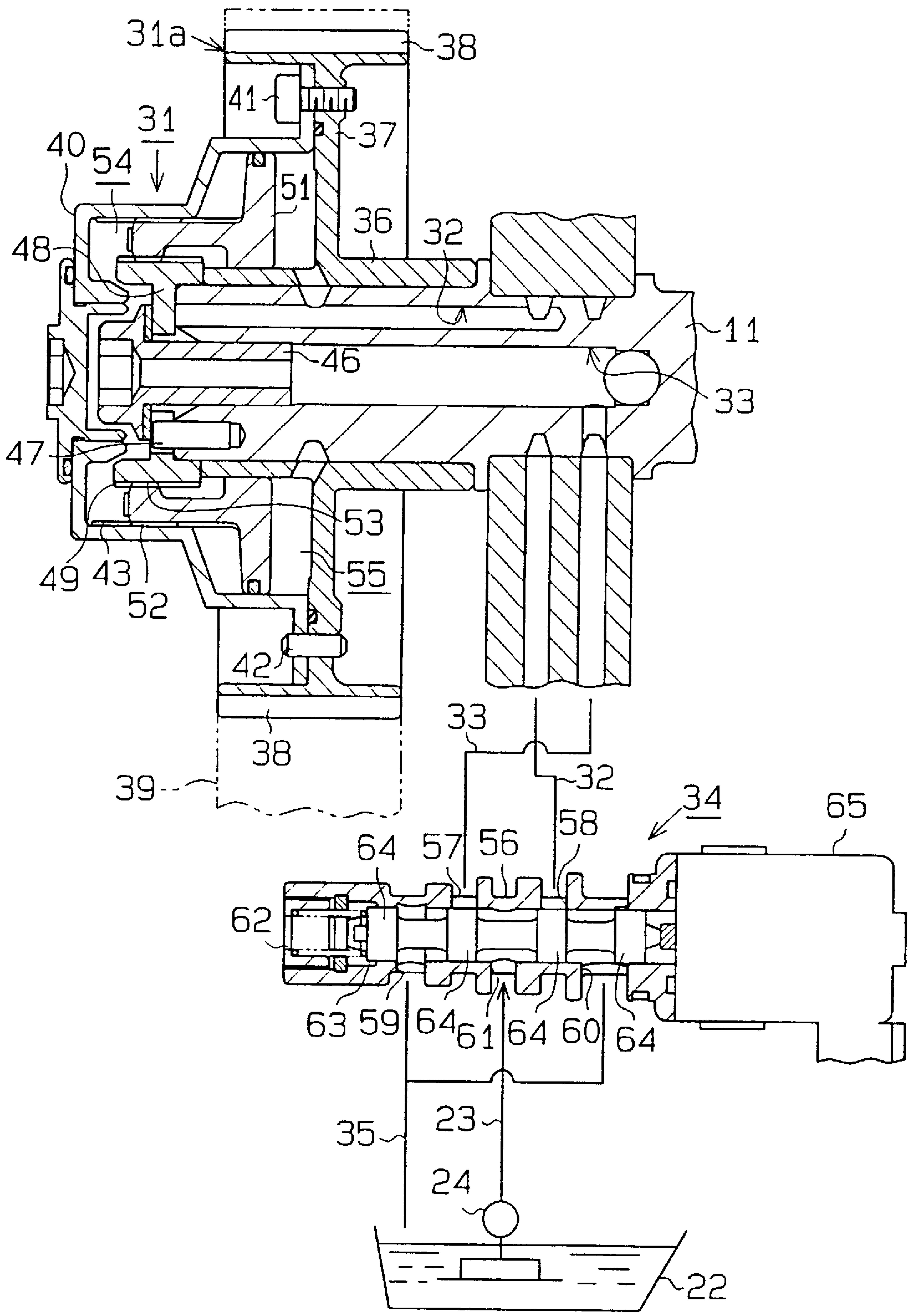

31a
38
41
37
31
40
54
51
36
32
48
11
46
33
47
53
55
49
43
52
42
38
33
32
39
34
65
58
57
56
64
62
63
59
64
61
64
60
64
35
23
24
22

Fig.4

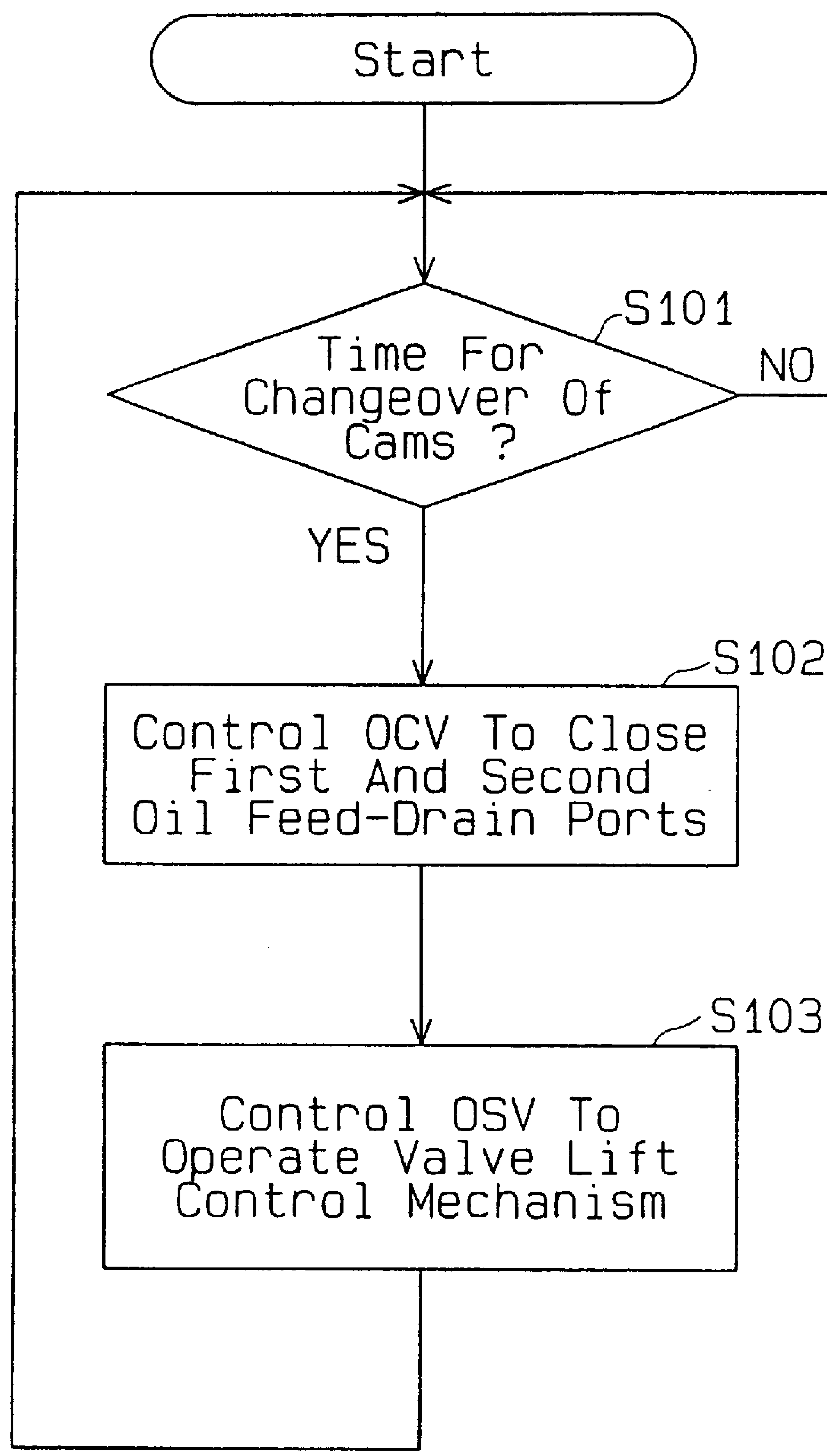

Start
Time For Changeover Of Cams ?
S101
NO
YES
S102
Control OCV To Close First And Second Oil Feed-Drain Ports
S103
Control OSV To Operate Valve Lift Control Mechanism

Fig.5

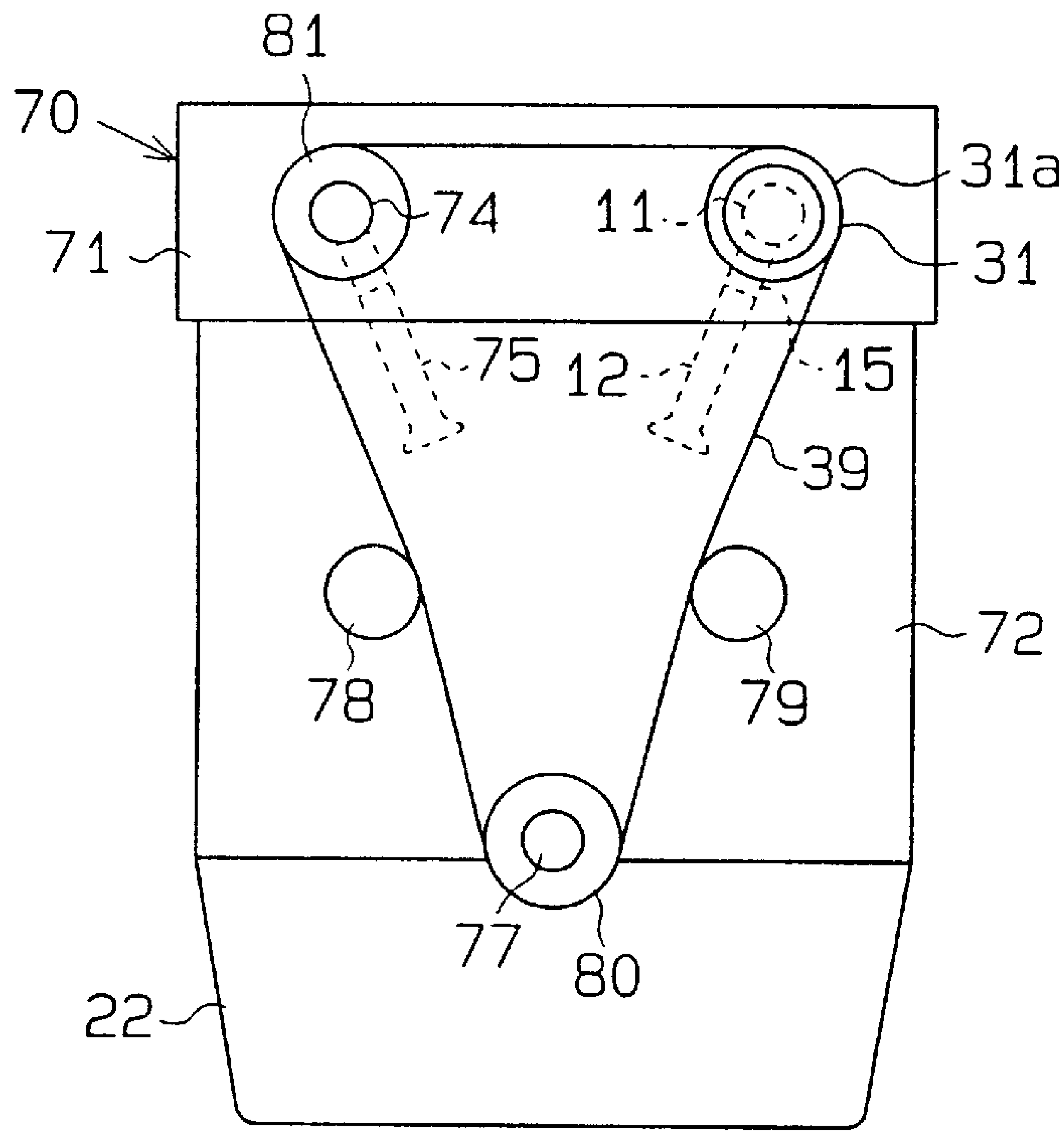
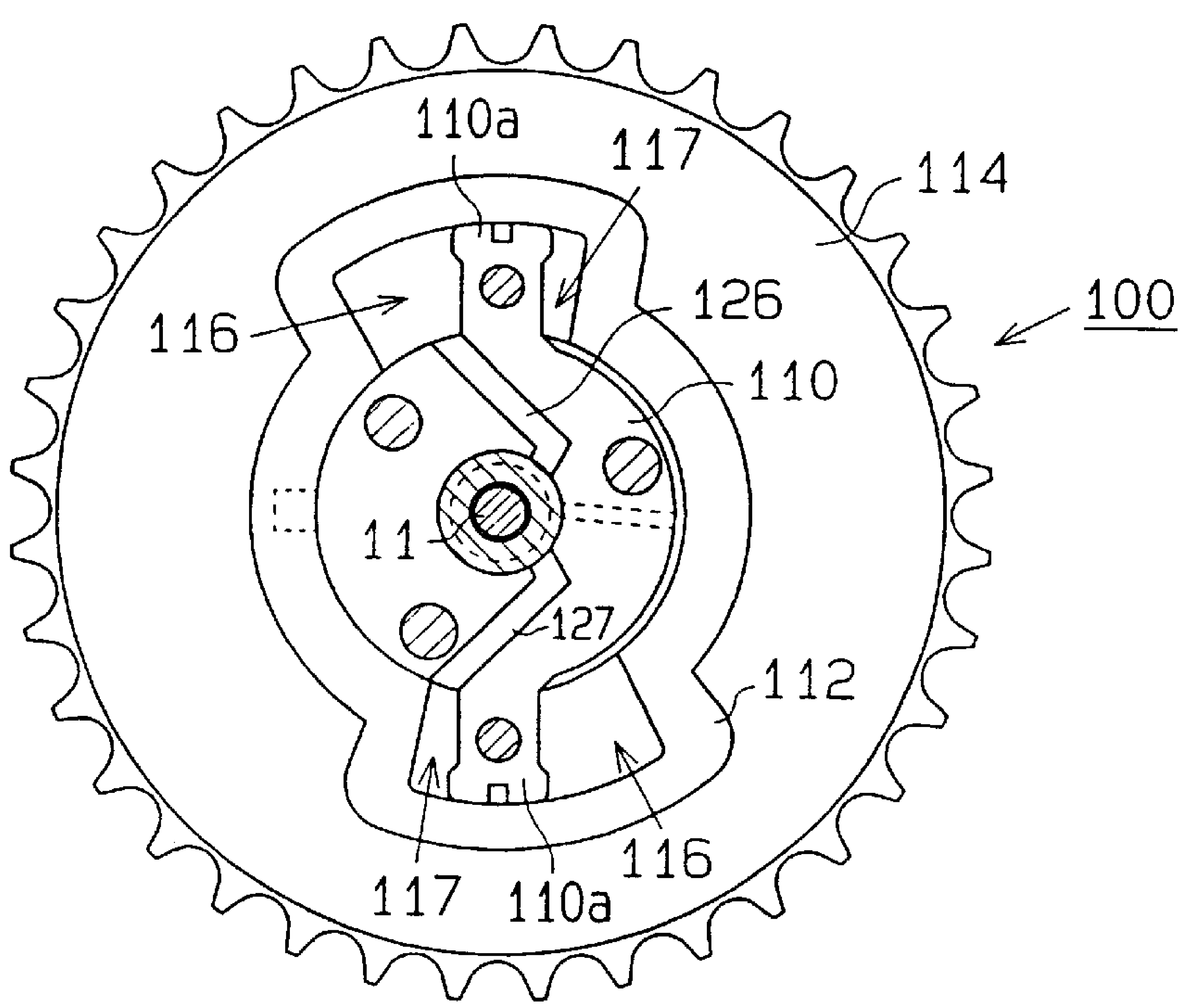

81
70
71
74
11
31a
31
75
12
15
39
78
79
72
77
80
22

Fig.6


110a
117
114
100
116
126
110
11
127
112
117
110a
116

VALVE PERFORMANCE CONTROLLER FOR INTERNAL COMBUSTION ENGINE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a valve performance controller for varying the valve timing and the valve lift in an internal combustion engine.

2. Description of the Related Art

In Japanese Unexamined Patent Publication No. 8-49514, a valve apparatus includes a camshaft, a valve timing control mechanism, and a valve lift control mechanism. The camshaft is connected to the crankshaft of an internal combustion engine via a timing belt. The camshaft is provided with a plurality of cams of different shapes for actuating valves. The valve timing control mechanism causes the camshaft to lead or lag the crankshaft to thereby vary the timing of actuating valves. The valve lift control mechanism selects a cam to actuate valves, thereby changing the lift of the valves.

In the conventional valve apparatus described above, the shapes of the cams and roughness of the contact surfaces of the cams vary. Thus, upon changing the active cam, the driving torque for rotating the camshaft fluctuates significantly, so that a large impact derived from the torque fluctuation acts on the timing belt. As a result, deterioration of the timing belt accelerates, resulting in a shorter replacement cycle for the timing belt.

SUMMARY OF THE INVENTION

The present invention has been accomplished to solve the above-mentioned problems, and an object of the present invention is to reduce the impact acting on a transmission device, such as a timing belt, upon changeover of cams.

To achieve the above object, the present invention provides an apparatus for controlling valve performance in an engine. The engine has a combustion chamber connected with an air intake passage and an air exhaust passage, an intake valve located in the intake passage to control airflow supplied to the combustion chamber from the intake passage, and an exhaust valve located in the exhaust passage to control exhaust airflow to the exhaust passage from the combustion chamber. Each of the valves is controlled to adjust airflow passing therethrough with a variable valve lift amount and a variable valve timing. A camshaft is provided with a plurality of cams of different shapes for actuating at least one of the valves. A first mechanism selects at lest one cam for actuating the actuated valve to alter a lift amount of the actuated valve. A second mechanism controls the valve timing. The second mechanism is provided on the camshaft. The second mechanism has a rotary member, a movable member, and first and second hydraulic chambers. The movable member couples the rotary member with the camshaft. The movable member moves to change the relative rotational phase between the rotary member and the camshaft. The first and second hydraulic chambers are provided respectively on opposite sides of the movable member. The chambers control movement of the movable member with hydraulic pressure. A transmission device transmits torque from the engine to the rotary member. Altering means alters the hydraulic pressure in the first and second chambers. The altering means selectively supplies hydraulic fluid to and drains hydraulic fluid from the first and second hydraulic chambers. Controlling means controls the altering means to charge and retain hydraulic fluid in the chambers during changing of the operative cam by said first mechanism.

Other aspects and advantages of the invention will become apparent from the following description, taken in conjunction with the accompanying drawings, illustrating by way of example the principals of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention, together with objects and advantages thereof, may best be understood by reference to the following description of the presently preferred embodiments together with the accompanying drawings.

FIG. **1** is a block diagram showing the configuration of a valve performance controller according to a first embodiment of the present invention;

FIG. **2** is a perspective view showing a valve lift control mechanism;

FIG. **3** is a sectional view showing a valve timing control mechanism and an oil control valve;

FIG. **4** is a flowchart illustrating valve lift control;

FIG. **5** is a diagrammatic front view showing an engine; and

FIG. **6** is a partial enlarged cross-sectional view showing a second embodiment of a valve timing control mechanism according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

A preferred embodiment of the present invention will now be described with reference to FIGS. **1** to **5**.

An engine **70** having a valve train that includes a valve timing control mechanism **31** and a valve lift control mechanism **15** is shown in FIG. **5**. The engine **70** includes an oil pan **22** for reserving lubricating oil, a cylinder block **72** provided with cylinders (not shown), and a cylinder head **71**. The cylinder head **71** supports camshafts **11** and **74**, exhaust valves **75**, and intake valves **12**.

The engine **70** has combustion chambers connected with air intake passages and air exhaust passages (not shown). The intake valves **12** are located in the intake passages to control airflow supplied to the combustion chambers from the intake passages. The exhaust valves **75** are located in the exhaust passages to control exhaust airflow to the exhaust passages from the combustion chambers.

The cylinder block **72** rotatably supports a crankshaft **77**. Tensioners **78, 79** are arranged at predetermined positions on the cylinder block **72**. The cylinder head **71** rotatably supports the camshaft **11** so as to open and close the intake valves **12**. The cylinder head **71** also rotatably supports the camshaft **74** so as to open and close the exhaust valves **75**. The valve timing control mechanism **31** is provided at a distal end of the camshaft **11**. The valve lift control mechanism **15** is provided between the valves **12** and the camshaft **11**. Pulleys **80**, **81**, **31***a* are provided at distal ends of the crankshaft **77**, the camshaft **74**, and the valve timing control mechanism **31**, respectively. A timing belt **39**, which serves as a transmission device, is wound about the pulleys **80, 81, 31***a*. Tension is applied to the timing belt **39** by the tensioners **78, 79**.

The rotation of the crankshaft **77** is transmitted to the camshafts **11, 74** by means of the timing belt **39** and the pulleys **80**, **81**, **31***a*. This rotates the camshafts **11**, **74** synchronously with the crankshaft **77**. The rotation of the camshafts **11, 74** selectively opens and closes the associated intake and exhaust valves **12, 75** in accordance with a predetermined timing.

As shown in FIGS. **1** and **2**, the camshaft **11** is provided with a high speed cam **13** and low speed cams **14***a* and **14***b* for the purpose of opening and closing the intake valves **12**. The high speed cam **13** is located between the low speed cams **14***a* and **14***b*. The high speed cam **13** has a cam profile different from that of the low speed cams **14***a* and **14***b* such that the lift of the valves **12** actuated by the high speed cam **13** is greater than that of the valves **12** actuated by the low speed cams **14***a* and **14***b*. Thus, the intake air volume of the engine **70** is decreased by opening and closing the valves **12** by means of the low speed cams **14***a* and **14***b* during low speed operation of the engine **70**, whereas the intake air volume is increased by opening and closing the valves **12** by means of the high speed cam **13** during high speed operation of the engine **70**.

The valve lift control mechanism **15** is provided between the valves **12** and the cams **13**, **14***a*, and **14***b*. As shown in FIG. **2**, the valve lift control mechanism **15** has a rocker shaft **16** parallel to the camshaft **11**.

A high speed rocker arm **17** is provided on the rocker shaft **16** at a position corresponding to the high speed cam **13**, and low speed rocker arms **18***a* and **18***b* are provided on the rocker shaft **16** at positions corresponding to the low speed cams **14***a* and **14***b*, respectively. The high speed rocker arm **17** is pivotable about the axis of the rocker shaft **16** relative to the rocker shaft **16**. The low speed rocker arms **18***a* and **18***b* are fixed on the rocker shaft **16**. Upper ends of the valves **12** are located under the distal ends of the low speed rocker arms **18***a* and **18***b*.

An oil feed-drain passage **19** extends through the rocker shaft **16** to the high speed rocker arm **17**. As shown in FIG. **1**, the oil feed-drain passage **19** is connected to an oil switching valve (OSV) **20** and an oil drain passage **21**. The drain passage **21** runs to the oil pan **22** provided at the lower portion of an engine **70**, so that oil drained from the oil drain passage **21** returns to the oil pan **22**.

An oil feed passage **23** is connected to the OSV **20** and to the oil pan **22** via an oil pump **24**. The oil pump **24** is connected to the crankshaft **77**, and is thus driven as the crankshaft **77** rotates. The OSV **20** is actuated and controlled by an electronic control unit (ECU) **25**.

Specifically, when the OSV **20** opens under control of the ECU **25**, the driven oil pump **24** feeds oil from the oil pan **22** into the high speed rocker arm **17** (FIG. **2**) via the oil feed passage **23**, the OSV **20**, and the oil feed-drain passage **19**. When oil is fed into the high speed rocker arm **17**, a coupler member (unillustrated) within the high speed rocker arm **17** moves to a position where the high speed rocker arm **17** and the low speed rocker arms **18***a* and **18***b* are coupled together. In this coupled state, the valves **12** are opened and closed by the high speed cam **13** via the high speed rocker arm **17** and the low speed rocker arms **18***a* and **18***b*.

When the OSV **20** is closed under control of the ECU **25**, oil retained in the high speed rocker arm **17** drains into the oil pan **22** via the oil feed-drain passage **19** and the oil drain passage **21** shown in FIG. **1**. When oil is drained from the high speed rocker arm **17**, the coupler member moves to a position where the high speed rocker arm **17** and the low speed rocker arms **18***a* and **18***b* are uncoupled from each other. In this uncoupled state, the valves **12** are opened and closed by the low speed cams **14***a* and **14***b* via the low speed rocker arms **18***a* and **18***b*.

As shown in FIG. **1**, the valve timing control mechanism **31** causes the camshaft **11** to lead or lag the crankshaft **77** to thereby vary the timing of actuating the valves **12**. An advance control oil passage **32** and a delay control oil passage **33** are formed in the valve timing control mechanism **31**. Oil is fed or drained through the advance control oil passage **32** and the delay control oil passage **33** under control of an oil control valve (OCV) **34**.

The oil feed passage **23** is also connected to the OCV **34**. In other words, the oil feed passage **23** branches into two passages downstream of the oil pump **24**, and the individual oil feed passages **23** are connected to the OCV **34** and the OSV **20**, respectively. An oil drain passage **35** is connected to the OCV **34**, so that oil drained from the oil drain passage **35** returns to the oil pan **22**. The OCV **34** is also actuated and controlled by the ECU **25**.

Next, the structures of the valve timing control mechanism **31** and the OCV **34** will be described in detail.

As shown in FIG. **3**, the valve timing control mechanism **31** has the pulley **31***a*. The pulley **31***a* includes a cylindrical portion **36** through which the camshaft **11** penetrates, a disk portion **37** projecting from the periphery of the cylindrical portion **36**, and a plurality of external teeth **38** formed on the periphery of the disk portion **37**. The pulley **31***a* is connected to the crankshaft **77** via the timing belt **39** engaged with the external teeth **38**. A cover **40** is fixed on the pulley **31***a* with a bolt **41** and a pin **42** to cover the end portion of the camshaft **11**. A plurality of internal helical teeth **43** are circumferentially arranged on the inner wall of the cover **40** in correspondence with the end portion of the camshaft **11**.

An inner cap **48** is fixed on the distal end of the camshaft **11** with a hollow bolt **46** and a pin **47**. A plurality of external helical teeth **49** are circumferentially arranged on the periphery of the inner cap **48** such that the external teeth **49** face the internal teeth **43** of the cover **40**. A cylindrical ring gear **51** is provided between the external teeth **49** and the internal teeth **43** and is movable in the axial direction of the camshaft **11**. The ring gear **51** has helical teeth **52** and **53** engaged with the internal teeth **43** and the external teeth **49**, respectively.

In the thus-structured valve timing control mechanism **31**, when rotation of the crankshaft **77** driven by the engine **70** is transmitted to the pulley **31***a* via the timing belt **39**, the pulley **31***a* and the camshaft **11** rotate in unison. As the camshaft **11** rotates, the valve **12** opens and closes as already mentioned. When the ring gear **51** moves toward the pulley **31***a* (rightward in FIG. **3**), the helical teeth **52** and **53** of the ring gear **51** cause the relative rotational phase between the pulley **31***a* and the camshaft **11** to change in a direction causing the camshaft **11** to lag the crankshaft **77**. As a result, the timing of actuating the valves **12** is delayed. By contrast, when the ring gear **51** moves toward the cover **40** (leftward in FIG. **3**), the helical teeth **52** and **53** cause the relative rotational phase to change in a direction causing the camshaft **11** to lead the crankshaft **77**. As a result, the timing of actuating the valves **12** is advanced.

Next the structural features of the valve timing control mechanism **31** associated with hydraulic movement of the ring gear **51** will be described.

The ring gear **51** divides the interior of the cover **40** into a delay hydraulic chamber **54** and an advance hydraulic chamber **55**. The advance control oil passage **32** and the delay control oil passage **33** formed in the camshaft **11** correspond to the advance hydraulic chamber **55** and the delay hydraulic chamber **54**, respectively. In other words, the advance control oil passage **32** communicates with the advance hydraulic chamber **55** through the cylindrical portion **36** of the pulley **31***a*, while the delay control oil passage **33** communicates with the delay hydraulic chamber **54** through the interior of the hollow bolt **46**.

The OCV **34** includes a casing **56**, which has first and second oil feed-drain ports **57** and **58**, first and second oil drain ports **59** and **60**, and an oil feed port **61**. A spool **63** having four valve portions **64** is provided within the casing **56** such that a coil spring **62** and a solenoid **65** apply force A to the spool **63** in opposite directions, respectively.

Specifically, when the solenoid **65** is de-energized, the spool **63** is urged within the casing **56** toward the solenoid **65** (rightward in FIG. **3**) by the elastic force of the coil spring **62**. As a result, the first oil feed-drain port **57** and the first drain port **59** communicate with each other, and the second oil feed-drain port **58** and the oil feed port **61** communicate with each other. On the other hand, when the solenoid **65** is energized, the spool **63** is urged within the casing **56** toward the coil spring **62** (leftward in FIG. **3**) against the elastic force of the coil spring **62**. The second oil feed-drain port **58** and the second oil drain port **60** communicate with each other, and the first oil feed-drain port **57** and the oil feed port **61** communicate with each other. Further, when power to the solenoid **65** is controlled such that the spool **63** is positioned at the middle of the casing **56**, the first and second oil feed-drain ports **57** and **58** are closed to inhibit oil from flowing through the first and second oil feed-drain ports **57** and **58**. The advance control oil passage **32** and the delay control oil passage **33** are connected to the second oil feed-drain port **58** and the first oil feed-drain port **57**, respectively; the oil feed passage **23** is connected to the oil feed port **61**; and the oil drain passage **35** is connected to the first and second oil drain ports **59** and **60**.

Next, operation of the valve performance controller **10** having the above-described structure will be described with reference to FIG. **4** and other relevant figures. FIG. **4** shows a valve lift control routine effected through the ECU **25**.

In step S**101** of the valve lift control routine, the ECU **25** determines whether to change the cams based on a signal received from an unillustrated sensor, which detects the rotational speed of the engine **70** or some indication of the engine speed. As already mentioned, whether to make a changeover of the cams depends on the current rotational speed of the engine **70**. When the ECU **25** judges that it is not time to change the cams, step S**101** is repeated. When the ECU **25** judges that it is time to change the cams, control proceeds to step S**102**.

When judging that it is time to change the cams, the ECU **25** controls the OCV **34** so as to close the first and second oil feed-drain ports **57** and **58**, thereby shutting off the advance control oil passage **32** and the delay control oil passage **33**. As a result of shutoff of the advance control oil passage **32** and the delay control oil passage **33**, oil is prohibited from being fed to or drained from the delay hydraulic chamber **54** and the advance hydraulic chamber **55**, so that oil is positively retained in the hydraulic chambers **54** and **55**. While the valve timing control mechanism **31** is maintained in this state, the ECU **25** controls the OSV **20** in step S**103** to actuate the valve lift control mechanism **15**, thereby changing from the low speed cams **14***a* and **14***b* to the high speed cam **13**, or changing from the high speed cam **13** to the low speed cams **14***a* and **14***b*.

As already mentioned, upon changing the cams to actuate the valves **12**, the torque for rotating the camshaft **11** fluctuates due to the differences in cam profile and roughness of the contact surfaces between the high speed cam **13** and the low speed cams **14***a* and **14***b*.

In the valve performance controller **10**, such torque fluctuations are appropriately dampened between the camshaft **11** and the pulley **31***a* by the oil retained in the delay hydraulic chamber **54** and the advance hydraulic chamber **55**. Specifically, when such torque fluctuations are transmitted to the ring gear **51**, a force is applied to the ring gear **51** in the axial direction of the camshaft **11**. This force is attenuated by virtue of the dampening action of the oil retained in the hydraulic chambers **54** and **55**.

When the advance control oil passage **32** and the delay control oil passage **33** are shut off by the OCV **34**, all oil discharged from the oil pump **24** is fed to the valve lift control mechanism **15**. Accordingly, even though the valve lift control mechanism **15** and the valve timing control mechanism **31** are hydraulically controlled through use of the single oil pump **24**, the valve lift control mechanism **15** is reliably operated with no need to increase the capacity of the oil pump **24**.

As described above, the present embodiment provides the following effects (a) to (c).

(a) Fluctuations in the driving torque of the camshaft **11** associated with changing the cams are dampened during transmission of the fluctuations from the camshaft **11** to the pulley **31***a* by oil retained in the delay hydraulic chamber **54** and the advance hydraulic chamber **55**. Accordingly, the impact of such fluctuations on the timing belt **39** is reduced.

(b) Upon changing the cams, the first and second oil feed-drain ports **57** and **58** of the OCV **34** are closed to shut off the advance control oil passage **32** and the delay control oil passage **33**. Accordingly, oil is fully retained in the delay hydraulic chamber **54** and the advance hydraulic chamber **55** very easily and efficiently.

(c) Upon changing the cams, the advance control oil passage **32** and the delay control oil passage **33** are shut off, so that all oil discharged from the oil pump **24** is fed to the valve lift control mechanism **15**. Accordingly, even though the valve timing control mechanism **31** and the valve lift control mechanism **15** are hydraulically controlled through use of the single oil pump **24**, the valve lift control mechanism **15** is reliably operated with no need to increase the capacity of the oil pump **24**. Thus, the power loss of the engine **70** is minimized. That is, an increase in the capacity of the oil pump **24** or installation of an additional oil pump **24** is not necessary.

The present invention may also be embodied, for example, in the following modified forms.

(1) In the illustrated embodiment, the valves **12** are opened and closed by means of either the high speed cam **13** or the low speed cams **14***a* and **14***b*. However, three or more kinds of cams may be employed, thereby expanding the range of selection of cams used for opening and closing the valves **12**.

(2) The reciprocating type valve timing control mechanism **31** of the illustrated embodiment may be replaced by a vane type control mechanism. For example, a vane type valve timing control mechanism **100** as shown in FIG. **6** may be employed. A vane type valve timing control mechanism like that shown in FIG. **6** is described in detail in U.S. Pat. No. 5,107,804, which is incorporated herein by reference.

The vane type valve timing control mechanism **100**, which is fixed to the end of the camshaft **11**, has a vaned rotor **110**, a housing **112** surrounding the rotor **110**, and a sprocket **114**. The rotor **110** has a pair of vanes **110***a*. The sprocket **114** and the housing **112** are integral and are rotatable with respect to the camshaft **11** and the rotor **110**. Further, this valve timing control mechanism **100** has chambers **116**, **117** on each side of the vanes **110***a*, the chamber **116**, **117** being formed by cooperation between the vanes **110***a* on the rotor **110** and the housing **112**. The sprocket **114** is connected to the crankshaft **77** with a timing chain (not shown), which serves as a transmission device. By selectively applying hydraulic pressure to the chambers **116, 117** through passage **126, 127**, the camshaft **11** is rotated clockwise or counterclockwise with respect to the sprocket **114**.

In the vane type valve timing control mechanism, the chambers **116, 117** are provided on opposite sides of each vane **110***a*, and oil is retained in the chambers **116, 117** to provide an effect similar to that of the present embodiment.

(3) In the illustrated embodiment, the first and second oil feed-drain ports **57** and **58** are closed during cam changing. However, the OCV **34** may have a structure such that the first and second oil feed-drain ports **57** and **58** communicate with the oil feed port **61** during the cam changing operation. In this case, the delay hydraulic chamber **54** and the advance hydraulic chamber **55** are continuously fed with oil during cam changes, so that oil is retained in the hydraulic chambers **54** and **55**, thus appropriately maintaining the damping effect of oil in the chambers **54** and **55**.

(4) In the illustrated embodiment, the single oil pump **24** is used to feed oil to both the valve lift control mechanism **15** and the valve timing control mechanism **31**. However, separate oil pumps may be employed to feed oil to the respective mechanisms **15** and **31**. In this case, even when one oil pump fails, either the valve lift control mechanism **15** or the valve timing control mechanism **31** can be operated with the other oil pump. Accordingly, one oil pump failure dose not disable both mechanisms **15** and **31**.

(5) In the illustrated embodiment, the oil pump **24** is connected to a crankshaft **77** to drive the oil pump **24** through rotation of the crankshaft **77**. However, the present invention is not so limited. For example, an electric motor may be provided to drive the oil pump **24**, so that the oil pump **24** is driven regardless of whether the crankshaft **77** is rotating or not.

(6) In the illustrated embodiment, the valve lift control mechanism **15** is hydraulically actuated. However, the valve lift control mechanism **15** may be actuated by other than hydraulic means, for example, by electric means.

Therefore, the present examples and embodiments are to be considered as illustrative and not restrictive and the invention is not to be limited to the details given herein, but may be modified within the scope and equivalence of the appended claims.

What is claimed is:

1. An apparatus for controlling valve performance in an engine having a combustion chamber connected with an air intake passage and an air exhaust passage, an intake valve located in the intake passage to control airflow supplied to the combustion chamber from the intake passage, and an exhaust valve located in the exhaust passage to control exhaust airflow to the exhaust passage from the combustion chamber, wherein each of said valves is controlled to adjust airflow passing therethrough with a variable valve lift amount and a variable valve timing, said apparatus comprising:

a camshaft provided with a plurality of cams of different shapes for actuating at least one of the valves;

a first mechanism for selecting at least one cam for actuating the actuated valve to alter a lift amount of the actuated valve;

a second mechanism for controlling the valve timing, said second mechanism being provided on the camshaft, wherein said second mechanism has a rotary member, a movable member, and first and second hydraulic chambers, wherein said movable member couples said rotary member with said camshaft, wherein said movable member moves to change the relative rotational phase between said rotary member and said camshaft, wherein said first and second hydraulic chambers are provided respectively on opposite sides of said movable member, and wherein said chambers control movement of said movable member with hydraulic pressure;

a transmission device for transmitting torque from the engine to the rotary member;

means for altering the hydraulic pressure in the first and second chambers, said altering means selectively supplying hydraulic fluid to and draining hydraulic fluid from said first and second hydraulic chambers; and

means for controlling said altering means to charge and retain hydraulic fluid in the chambers during changing of the operative cam by said first mechanism.

2. The apparatus according to claim **1**, wherein said first and second hydraulic chambers communicate with first and second oil passages, respectively, wherein said altering means includes a control valve for controlling oil flow in the first and second oil passages, and wherein said control means controls said control valve so as to close said first and second oil passages when said first mechanism changes the operative cam.

3. The apparatus according to claim **2**, wherein said first mechanism is hydraulically actuated, and wherein said altering means includes an oil pump for feeding oil to said first mechanism and said first and second hydraulic chambers.

4. The apparatus according to claim **3**, wherein said oil pump is driven by said engine.

5. The apparatus according to claim **1**, wherein said movable member is axially movable relative to said rotary member and said camshaft, and wherein said movable member is coupled to said rotary member and said camshaft through gear engagement, such that when said movable member is axially moved, the relative rotational phase between said rotary member and said camshaft changes.

6. The apparatus according to claim **1**, wherein said movable member is a vaned rotor that is connected to said camshaft and is rotatable relative to said rotary member.

7. An apparatus for controlling valve performance in an engine having a combustion chamber connected with an air intake passage and an air exhaust passage, an intake valve located in the intake passage to control airflow supplied to the combustion chamber from the intake passage, and an exhaust valve located in the exhaust passage to control exhaust airflow to the exhaust passage from the combustion chamber, wherein each of said valves is controlled to adjust airflow passing therethrough with a variable valve lift amount and a variable valve timing, said apparatus comprising:

a camshaft provided with a plurality of cams of different shapes for actuating at least one of the valves;

a first mechanism for selecting at least one cam for actuating the actuated valve to alter a lift amount of the actuated valve;

a second mechanism for controlling the valve timing, said second mechanism being provided on the camshaft, wherein said second mechanism has a rotary member, a movable member, and first and second hydraulic chambers, wherein said movable member couples said rotary member with said camshaft, wherein said movable member moves to change the relative rotational phase between said rotary member and said camshaft, wherein said first and second hydraulic chambers are provided respectively on opposite sides of said movable member, and wherein said chambers control movement of said movable member with hydraulic pressure;

a transmission device for transmitting torque from the engine to the rotary member;

first and second oil passages communicated with said first and second hydraulic chambers, respectively;

an oil pump for feeding oil to said first and second hydraulic chambers via said first and second oil passages;

a control valve for controlling oil flow in the first and second oil passages, said control valve selectively supplying oil to and draining oil from said first and second hydraulic chambers; and

means for controlling said control valve so as to close said first and second oil passages to charge and retain oil in the chambers during changing of the operative cam by said first mechanism.

8. The apparatus according to claim **7**, wherein said movable member is axially movable relative to said rotary member and said camshaft, and wherein said movable member is coupled to said rotary member and said camshaft through gear engagement, such that when said movable member is axially moved, the relative rotational phase between said rotary member and said camshaft changes.

9. The apparatus according to claim **8**, wherein said rotary member is composed of a pulley and a pulley cover, wherein said movable member is a ring gear, which has external helical teeth engaging with internal helical teeth formed on the inner surface of said pulley cover and internal helical teeth engaging with external helical teeth formed on an inner cap attached to said camshaft.

10. The apparatus according to claim **9**, wherein said first mechanism is hydraulically actuated, and wherein said oil pump feeds oil to said first mechanism and said first and second hydraulic chambers.

11. The apparatus according to claim **10**, wherein said oil pump is driven by said engine.

12. The apparatus according to claim **7**, wherein said movable member is a vaned rotor that is connected to said camshaft and is rotatable relative to said rotary member.

* * * * *